



Enhancement Student Understanding Through the Development of Lab Module Based on Constructivistic

Wiharyanto Oktiawan¹, Mochtar Hadiwidodo¹, Purwono²

¹Department of Environmental Engineering, Faculty of Engineering, Universitas Diponegoro
Jl. Prof. H. Sudarto, SH., Tembalang, Semarang, Central Java
²IAIN Surakarta, Kartasura, Indonesia

Email: w.oktiawan@yahoo.com

ABSTRACT - Experimental focuses learning on developing the skills of student in the process of knowledge, discover and develop their own fact, concept, and values required. The way to make it is by doing modification to the practical guidance module had been given. Nowadays, practical guidance tend to emphasize on the explanation, so its use both practical and follow the path that has been presented. The practical guidance module should be modified based on constructivism. The module is an experimental guidance to environmental laboratory subject. The test material consists of water and wastewater sample with parameter of chemical oxygen demand (COD), total dissolved solid (TDS), and nitrate. The results showed progress in the cognitive aspects such students' ability to predict the concentration of COD sample. The greater COD concentration of wastewater make the color of mixture is blue-green. The student could communicate the calibration curves correctly. Hypothesis skills presented at TDS testing. The greater of the sediment, the greater the concentration of its. The same thing happened on COD testing, COD levels can be estimated earlier. The skills show an increasing such as the skill to ask questions, experiment planning skills, skills in using tools/materials, accuracy in data retrieval, seriousness and cooperation in conducting the experiment.

Keywords: Experimental Guidance, Constructivism, Environmental Laboratory, science process skills.

Submission: March 21, 2018

Correction: October 27, 2018

Accepted: March 2, 2019

Doi: <http://dx.doi.org/10.12777/ijee.1.1.41-45>

[How to cite this article: Oktiawan, W., Hadiwidodo, M., Purwono, P. (2019), Enhancement Student Understanding Through the Development of Lab Module Based on Constructivistic. *International Journal of Engineering Education*, 1(1), 41-45. doi: <http://dx.doi.org/10.12777/ijee.1.1.41-45>]

I. INTRODUCTION

Environmental Engineering Program is one that is under engineering faculty, University of Diponegoro. Environmental Engineering Program comes as a study program to apply thought and technique as well as management to maintain and protect the health and safety of humans and the environment as a whole. Environmental Engineering is a study program that seeks to solve the problems of environmental technological approach. The scope of the field of Environmental Engineering is the conservation of water resources, environmental management, environmental health management, efforts to control pollution, sewerage and effluent, control of pollution caused by waste water, gas and sludge (sludge) and water quality management, soil and atmosphere, as well as the control and management of environmental impacts.

Environmental engineering is described as thinking skills in solving engineering and environmental control issues regarding the provision of drinking water; the waste disposal and recycling system liquid, solid, and

gas; urban and rural drainage system and environmental sanitation; pollution control and water quality management, soil and air; as well as the control and management of environmental impacts.

One of the Faculty of Engineering's mission is to provide education that is superior (excellent) in the field of engineering and technology, so as to produce graduates with a competitive advantage. In order to realize this mission, one of the 'rungs' prepared to improve the quality of learning. In line with this, one of the study served to satisfy the competence of learners in Environmental Engineering Program is a practicum courses. One practicum courses that its existence is essential is the subject of laboratory environment. It is because of this course is the foundation course associated with other practicum courses are unit processes, the management of industrial waste, hazardous and toxic materials, ecotoxicology, monitoring air quality. Subjects practical lab environment contains a study of the methods of sampling and preservation of samples, analysis, physical and chemical water, soil and waste such as:

characteristics of water, soil and waste, organic compounds in waste, dissolved oxygen, BOD, COD, nitrogen, metals weight, determination of mud and sludge volume index, phosphate, basics of analysis of water pollution and solid effluent.

According Adisenjaja (2008) practicum is not only useful and essential to understand the theory but also aims to train students to become scientists or engineers as well as help students learn a concept or to develop attitudes and interests. Practicum must be seen and understood that in practical skills useful in the real world in line with the increasing advancement of science and technology. Skills and hands-on activities will instill confidence and will be useful in everyday kehidupan (Wiedenbeck et.al., 2000).

Learning practicum courses focus on developing the skills of learners in memproseskan knowledge, discover and develop their own facts, concepts, and values required. This is consistent with what is called science process skills. Science process skills are measures used by scientists when they identify problems and work to solve the problem, the scientists found science process skills arising in the mind spontaneously and naturally, used to divide mind into steps logical and find the answer to how we work in the world around us, and is used not only in science but in all situations require critical thinking (Rustam, 2003). It aims to bring people who can do the research, ask questions, achieve scientific knowledge by using scientific thinking, and even use the knowledge to solve problems encountered in daily life (Buntod et.al., 2010; Cakir, 2010).

On the other hand, the environmental laboratory practicum courses occur several issues regarding the condition of science process skills of students. It can be seen from the theoretical understanding is not in line with the practice of the skills possessed by most students. Another fact that many students who ask questions related to manual procedures especially of interest reagent additions and treatment phase. This ni experienced both when doing practical work and thesis.

As one of the solutions in improving science skills of students, instructional modifications should be implemented. One way is to do modifications to the model given practical guide. Free practicum that there be a practical guide that tends behavioristik and more emphasis on the exposure, so its use is practical to follow the path that has been presented. Modifications to do with the practical guide based on constructivism greater emphasis on understanding the construction of learners.

II. METHODS

The learning management study to evaluate the response of students to learning constructivism presented, as well as a description of how science process skills possessed by students. Description of process skills can be classified as thinking skills (Phardan, 2000; May 2007;). Thinking skills that are categorized as science process skills are intellectual skills (Dahar, 2003). According Rambuda and Traser (2004), thinking skills and science skills are divided into three aspects, namely asepek cognitive, psychomotor, and affective. In

this research, science process skills indicators of coverage include:

Cognitive aspects

Cognitive aspects of science process skills include the following:

- a. Skills predict the ability of estimating something that has not happened based on facts that show a trend or pattern that already exists.
- b. The ability to communicate is the ability to describe and read graphs, tables or charts.
- c. The ability to apply the concept is the ability to apply the concepts learned in new situations.
- d. Skills interpret data that is the ability of finding a pattern or keteraturan based on the experimental data and draw a conclusion from the results of the experiment.
- e. Skills hypothesis that the ability of the relationship between the two variables.

Psychomotor aspects

Psychomotor aspects include:

- a. Observing skills: the ability to identify the phenomenon and the similarities and differences of a particular object by means of the senses carefully.
- b. Skills asking the question is the ability of asking the question of what, why, and how to ask for an explanation about something that background hypothesis.
- c. Skills to plan experiments that determine the ability of the equipment and materials needed in the investigation, determine what is observed, measured or written.
- d. Skills in using tools / materials is the ability to use tools / materials properly, and knowing how to use tools / materials.

Affective aspects

Science process skills of students is an attitude during the learning process that includes

- a. Accuracy in data retrieval,
- b. The seriousness in conducting the experiment,
- c. Cooperation in discussions and experiments, and
- d. Honesty in data retrieval.

In the pre-implementation stage of practical guidance based on constructivism, used instrument in the form form learning scenarios, learning observation sheets, as well as review the form of learning. In the implementation phase conducted practical guide to learning the instrument in the form of classroom achievement test and non-test. Quantitative data can be analyzed in a descriptive way.

III. RESULTS AND DISCUSSION

The study involves learning management students, especially the 2nd half Environmental Engineering Program, Faculty of Engineering, University of Diponegoro. The material consists of rigorous lab testing of water and wastewater samples with test parameters are *chemical oxygen demand (COD)*, *total dissolved solids (TDS)* and nitrate (NO_3^-). The study was conducted in

laboratory water Environmental Engineering Program, Faculty of Engineering, Universitas Diponegoro by the number of participants of 20 students were divided into 5 groups. In other words, each group consisted of four students. Selection is based on the testing of basic methods and is often used in testing samples of water and wastewater. The methods are:

- a. Gravimetry
- b. Spectrophotometry

Gravimetric method represented by parameter TDS while spectrophotometric method represented by parameter COD and nitrate.

3.1. Cognitive aspects

Skills Forecasting

The cognitive aspect is the science process skills in environmental laboratory practicum courses are predicting skills. Students are able to predict the levels of COD sample prior to measurement. COD levels of water or wastewater the greater, then the color of blue-green mixture. At the time of the study, students can estimate that the COD value in the range values below 100 ppm or greater than 100 ppm. These estimates will determine the optimum wavelength utilization in absorbance measurement.

Different things happen in the TDS parameter testing and nitrate. Students are not able to estimate the level range of the parameter. This happens due to physical color sample and reagent mixture does not cause discoloration. The interesting thing in this test that students can estimate the levels of nitrate and TDS in a sample based on this water source. Clean water containing nitrate and TDS smaller than the wastewater.

Ability to Communicate

Other cognitive aspect is the ability to communicate. Students have the ability to describe and read graphs, tables or charts in detail. Testing of COD and nitrates contained calibration curve between concentration vs absorbance. Students are asked to create a calibration curve based on lab manual, the data obtained is then graphed between levels as the x-axis and absorbance as the y-axis. Then from the graph linear equations raised $y = ax + b$ and R squer (R^2). This chart applies to COD and nitrate test. Hold on to the student klaibrasi curve can explain the descriptive use of the curve. A calibration curve is required to have a minimum of $R^2 = 0.99$, less than 0.99 when it should be repeated. The interesting thing in this study is that students are able to conclude their test result is valid or not. Each of the calibration curve has a maximum COD concentration of 500 ppm and 100 ppm lows. COD standard solution 500 ppm resulted in absorbance at 108 ppm 0.163 and the lowest yield 0.047 absorbance as in the table 1.

A main feature of the communication aspect of students such as students demonstrate the ability to use the curve. If the sample absorbance measurement exceeds the maximum absorbance curve then the samples must be diluted beforehand. Besides communication calibration curve, the student is able mengkomunikasikan

procedures manual testing tools use COD, nitrate and TDS. The tools used are oven, COD reactor, micro pipettes, analytical balance, and UV-Vis spectrophotometer. Students understand and properly follow directions on the instrument.

Table 1: Levels of standard solution of COD and absorbance value

No.	Concentration (ppm)	Absorbance
1	108	0,047
2	206	0.075
3	304	0,105
4	402	0.136
5	500	0.163

Based on the above table is then created a calibration curve as following figure:

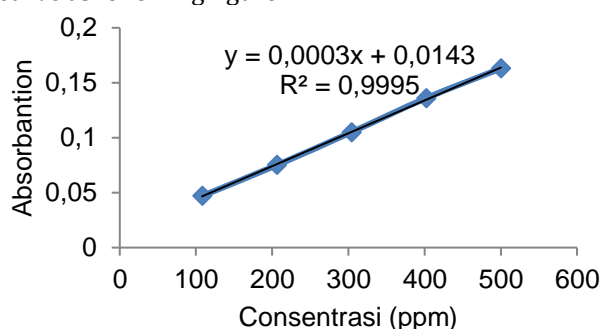


Fig 1: Calibration curve COD levels 108 ppm to 500 ppm.

The ability of data interpretation

Skills interpret data that is the ability of finding a pattern or keteraturan based on the experimental data and draw a conclusion from the results of the experiment. Interpret data based on indicators of skills, the students were able to find a pattern. In testing the COD and nitrate apply the greater the absorbance the greater the concentration. Lambert-beer law is based on the amount of absorption (a) proportional to the magnitude of the concentration (c) of the test substance. Mathematically beer-lambert law expressed by the equation:

$$a = \epsilon bc$$

Where:

ϵ = epsilon or molar absorptivity ($m^{-1} cm^{-1}$)

b = slit width (cm)

c = concentration (m)

Ability hypothesis

Skills hypothesis that the ability of the relationship between the two variables. At the time of testing TDS precipitate which further weighed on analytical balance. The more precipitate, the greater the value of its TDS. The same thing happened on testing COD, COD levels can be detected earlier. If the sample preparation phase by adding a solution of digestion and concentrated sulfuric acid (H_2SO_4) in the sample it will produce a color change from orange-green-blue. Orange color indicates

low levels of COD and green to blue indicating high levels of COD. Mendakan orange color levels of $\text{Cr}_2\text{O}_7^{2-}$ digestion solution is still high. High levels of $\text{Cr}_2\text{O}_7^{2-}$ mean reduction reaction $\text{Cr}_2\text{O}_7^{2-}$ small, in other words the levels of pollutants (organic) bit. Green-blue color mengindikasikan that high levels of COD samples. This color is formed by organic and inorganic compounds, mainly organic in the test sample is oxidized by $\text{Cr}_2\text{O}_7^{2-}$ in the closed reflux produce Cr^{3+} green-blue (Manahan, 2010).

3.2. Aspects Psychomotor

Psychomotor is the domain-related skills (skills) or the ability to act after the student receives specific learning experience. psychomotor is associated with physical activity as follows:

Observing skills

The ability to observe the ability to identify the phenomenon and the similarities and differences of a particular object by means of the senses carefully. Skills observe the most prominent points based on the results of this study. Armed with practical guidelines that have been modified in such a way adopting konstruktivistik learning, students are able to observe and identify phenomena every step of the experiment. Chemical analysis relies heavily on color change when the sample plus reagent (Manahan, 2010) .. Testing COD parameter will cause a color change from orange to green to blue. This color arises akibat reaction between organic material with Cr^{6+} color forming Cr^{3+} . Students are able to observe the onset of deposition upon heating COD. The presence of sediment indicates a Cl^- which act by forming precipitates AgCl Ag catalyst.

At trial nitrate is not so visible color change after adding reagent sample. Samples containing nitrate when added HCl 1 N will produce a clear coat or appropriate color original sample. The observations made in the form of students that their impurities or colloidal suspensions. If there colloidal then the student decided to do a first screening to separate colloids. The presence of colloids will disrupt the sample absorbance at 220 nm wave had long and 275 nm.

TDS experiment focuses on the amount of sludge generated during heating. Students are able to observe carefully the beginning of the formation of deposits that indicate the number of dissolved solids in water.

Skills asking questions

Students are more observant and have questions when reading the practical guide based approach konstruktivistik. Lab module earlier tend to require students to perform an activity but does not mention the destination of such treatment. Skills asking the question is the ability of asking the question of what, why, and how to ask for an explanation about something that background hypothesis. Looks at a significant change of skills to ask questions. The question that arises is dominated by the goal of reagent addition and why dilakukan steps. For example COD test using a solution digestion of low and high. Based on the explanation diktat practical guide

mentioned that the sample had a COD content of less than 90 mg / l then use a low digestion solution. While samples containing COD levels of 100-900 mg / l, the use of high digestion solution. then ask students questions why this should be distinguished.

Other questions related to the steps to create a solution. Diktat instructions listed practical guide as how to create a solution preparation 1 N HCl solution by diluting concentrated HCl 82.2 ml with distilled water to 1000 ml. In testing the TDS students questions why the weighing should be done to a constant weight.

Skills planned trial

Students are able to plan experiments. Merencanakan trial skills is the ability determine the tools and materials needed in the investigation, determine what is observed, measured or written. diktat practical guide provides tools and materials and work steps. they are quite skilled will determine which tools they use and how to use it. guide to the use of the tools already available on each of the foreign instrument.

Skills in using tools / materials

Skills in using tools / materials is the ability to use tools / materials properly, and knowing how to use tools / materials. Students' skills using chemicals would have to know in advance the rules or the rules of use of chemicals. Knowing the rules is intended that students can understand correctly how to use chemicals before working with chemicals, so as to prevent accidents in the laboratory. The results showed that the students are able to:

1. Read the label names of chemicals carefully before taking the contents and use. Each discuss practicum have certain properties such as danger, toxic, irritant, explosive, or flammable.
2. Student use of chemicals with the appropriate amount in accordance with the user manual work procedures have been determined, no more and no less. if excessive in taking chemicals, return it to the container / bottle before.
3. Students avoid activities that do not joke like tasting chemicals in the laboratory, not touch / hold chemicals with their bare hands.
4. Students do not smell / gas arising from chemical or chemical reaction proceeds directly, but use your hand to wag gas toward the nose.
5. Students are able to cope with the chemicals spilled or clothing exposed to chemicals in a way to wash with running water.
6. After working with chemicals, student men to clean hand washing before eating, drinking, or smoking.
7. Students men utup back bottles of chemicals, bottles of reagents or other materials after use.

3.3. Affective aspects

Affective aspects of science process skills is an attitude of students during the learning process that includes:

Accuracy in data collection

Data once lab results less reliable because it may be repeated if the measurement is to be obtained different data. Intuition we declare each measurement is made will obtain more complete information about the actual value. How many measurements should be done? How do I determine the value of the best approach? How to determine the deviations from the true value? When the measurement of time what is the level of confidence? What if the measurement time where?

Students skilled retrieve data by conducting testing lab sebanyak 2 times (Duplo) in other words the same sampel tested 2 times. Their results are not directly averaged But the data do the testing beforehand stock. If the difference in the test are in the range of less than 5% of the feed data is averaged. if more than 5%, the students perform additional testing of the same sample. The results obtained were then compared with the data returned Duplo. The third difference value data to produce a difference of 5%, then do average.

The seriousness and cooperation in conducting experiments

The results showed that serious students in the experiment. They tried to follow the directives presented in praktikum instructions well and do a practicum in an orderly manner. Based on observations of practical implementation, student mutual cooperation and discussion related to the difficulties. They reminded each other and provide an opportunity for group members to take turns using the tool.

IV. CONCLUSIONS

2nd semester student of environmental engineering, Department of Environmental Engineering, Faculty of Engineering, Universitas Diponegoro can predict, communicate, apply concepts, interpret data environment laboratory practicum courses. They can observe, ask questions, plan experiments, using the tools / materials properly. They shows the thoroughness, seriousness, cooperation and honesty in data retrieval practicum.

Acknowledgments

The authors would like to thank Faculty of Engineering, Diponegoro University for providing fund during the research. The authors would also like to environmental laboratory, Department of environmental engineering, Faculty of Engineering, Diponegoro University for supporting laboratory facility.

References

- [1]. Buntod, PP, Suksringam, P. and Singseevo, A. 2010. "Effects of Learning Environmental Education on Science Process Skills and Critical Thinking of Mathayomsuksa 3 Students with Different Learning Achievements". *Journal of Social Sciences*. 6 (1): 60-63.
- [2]. Cakir, NK and Sarikaya, M. 2010. "An evaluation of the science process skills of the science teaching majors. Gazi University, Faculty of Gazi Education, Primary Science Education, Turkey ". *Procedia. Procedia Social and Behavioral Sciences* 9, 1592-1596.
- [3]. Dahar, RW & N. Siregar. 2000. Pedagogy Subject matter: Laying the foundation of the Scientific of PBM". Papers at the Seminar Lecturer FPMIPA staff in order to socialize Pedagogy Subject matter. UPI, Bandung.
- [4]. Manahan, SE 2010. Environmental Chemistry Edition 9. United States of America: CRC Press.
- [5]. May GTY 2007. "Promoting Science Process Skills And The Relevance Of Science Through Science Alive! Programme " *Proceeding of the Redesigning: Culture, Knowledge and Understanding Conference*, Singapore, May 2007.
- [6]. Phardan, Harcharan. 2000. "Science Activities and Ideas Experiencing Science Process Skills". Teacher's Resource. University Of Alberta. [Access dated June 13, 2016].
- [7]. Rambuda and Fraser. 2004. "Perceptions of teachers of the application of science process skills in the teaching of Geography in secondary schools in the Free State province". *South African Journal of Education* .Vol 24 (1)10-17. Roestiyah (1985).
- [8]. Rustam, N 2003. Scientific Process Capability in Science Learning. Bandung: University of Indonesia.
- [9]. Wiedenbeck, JA Zavala, Z. & Nawyn, J. 2000. An activity-based analysis of hands-on practice methods. *Journal of Computer Assisted Learning*. 16, 358-365